Adaptive Transmit Diversity and Spatial Multiplexing for MIMO-OFDM Systems

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Abstract. Space-time block coding (STBC) and Spatial multiplexing (SM) or BLAST (Bell Labs Layered Space-Time) are promise approaches that exploit the MIMO channel to provide higher data rates and diversity gains with no sacrifice in bandwidth. In this work, we present a hybrid MIMO scheme that combines transmit diversity and spatial multiplexing. The proposed scheme can achieve arbitrary number of multiplexing rate.

Keywords: MIMO, Space-Time block coding, V-BLAST.

1 Introduction

Multiple-input multiple-output (MIMO) wireless channels are known to offer better link and/or capacity gains, which can be exploited by employing antenna arrays at both ends of link [1]. Most MIMO schemes are designed to achieve just one of two available gains from these system [2], [3]. There is, however, a trade-off: a compromise between spectral efficiency and diversity gain can be expected in the case of considering different MIMO implementations. Some schemes called hybrid MIMO schemes consisting of STBC and spatial multiplexing schemes combine transmit diversity and spatial multiplexing at the same time [4]. The work in [4] can achieve integer rates, but are not possible to achieve non-integer rates. In this paper, we propose a hybrid MIMO scheme to flexibly maximize the tradeoff between multiplexing and diversity gains.

2 System Model & Proposed Scheme

In this paper, we focus on multicarrier system using $N_c$ orthogonal subcarriers. Let us denote $N$ and $M$ as the number of transmit and receive antennas, respectively. The receive symbol vector on the $k$-th subcarrier can be expressed as

$$X(k) = G(k)S_k + V(k),$$  (1)

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where $S_k$ denotes the vector of transmit symbols, $H(k)$ denotes the channel matrix and $V(k)$ is the $M \times 1$ additive white Gaussian noise (AWGN) vector with zero mean and unit variance.

In proposed scheme, If we want to get a higher rate, we can transform matrix $S_i$ as this example

$$
S^1 = \begin{bmatrix}
s_1^1 & s_2^1 & s_3^1 & s_4^1 & s_5^1 & s_6^1 & s_7^1 & s_8^1 \\
s_1^2 & s_2^2 & s_3^2 & s_4^2 & s_5^2 & s_6^2 & s_7^2 & s_8^2
\end{bmatrix},
$$

(2)

$$
S^2 = \begin{bmatrix}
s_1^* & -s_2^* & -s_3^* & -s_4^* & -s_5^* & -s_6^* & x_9^1 & x_{10}^1 \\
s_1^* & s_2^* & s_3^* & s_4^* & s_5^* & s_6^* & x_2^2 & x_{10}^2
\end{bmatrix}.
$$

(3)

We have introduced new symbols $x_9^1, x_9^2, x_10^1$ and $x_10^2$, in matrix $S$ without changing the system model. As we transmit more symbols, the rate increases. This is clear since in (2),(3) we send 20 symbols in 8 subcarriers during 2 time slots. The rate of the proposed scheme is

$$
r = \frac{N_{STBC}^S + N_{SM}^S \times L}{N_C \times L} = \frac{12 + 4 \times 2}{8 \times 2} = 1.25.
$$

(4)

The proposed scheme uses two MMSE filters. To be able to use two MMSE filters, it is necessary to define two system models. As an example, in submatrix (2) and (3) we apply STBC-MMSE filter for the first 6 subcarriers to decode symbols, given by

$$
\begin{bmatrix}
\hat{s}_k^1 \\
\hat{s}_k^2
\end{bmatrix} = W_{STBC} R(k),
$$

(5)

where $k$ is the set of subcarriers which STBC is applied, and then we apply SM-MMSE filter for the next 2 subcarriers to decode symbols, given by

$$
\begin{bmatrix}
\hat{s}_k^1 \\
\hat{s}_k^2
\end{bmatrix} = W_{SM} R(k),
$$

(6)

where $k$ is the set of subcarriers which SM is applied.

3 Performance Result & Conclusion

In this section, we present the performance of the proposed scheme in terms of the BER versus the SNR and comparing our scheme with conventional schemes. We assume a MIMO system with $N=2$, $M=2$ and $N_c=128$. We evaluate SM (rate 2), proposed schemes(rate 1.25 and rate 1.06) and STBC (rate 1). In Fig. 1, it is shown that the diversity gain is decreased when the rate is high. This result is acquired because the proposed scheme uses many subcarriers for spatial multiplexing and little subcarriers for diversity gain.

In this work, we have proposed the hybrid MIMO scheme, where can be a flexible space-time code in terms of adjustable rate. With the proposed scheme, it is possible to reach non-integer values for its rate and obtain an optimized tradeoff between diversity and multiplexing gain according to the system requirements.
Fig. 1. BER performance comparison of the proposed scheme and the conventional schemes in 2x2 MIMO-OFDM system.

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